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ELECTRIC CAST IRON PIPE AND PREPARED, OR FACTORY-MADE, LEAD JOINTS[1]

By Harry Y. Carson[2]

Humble as were the installations of cast iron pipe two or three hundred years ago, today the arteries supporting the very life of every large modern city of the world consist of cast iron. Their important service to the community and the large investment in them warrant a careful study of any improvements that are offered.

Piping must be of sufficient strength to resist the practical conditions of handling, transporting, laying in trenches, and such external and internal pressures and shocks as may from time to time arise. The ability of the individual lengths of pipe to withstand the stresses *before* they are actually put into permanent service depends entirely upon the inherent strength of the metal itself; but, as a finished line, the combined effect of the stresses due to pressure, shock, water-hammer, contraction, expansion and deflection will mostly depend upon the resiliency of the joints between the individual pipes. Joints in service must be flexible, yet remain tight.

Factory-made prepared joints.[3] When one considers the rapid strides made in factory processes for eliminating the high cost of doing work, the novelty of a factory-made lead joint for cast iron pipe does not appear irrational. Take, for example, the large amounts of labor that are now saved on shoes, on clothes, on building, and, indeed, on almost everything we use, by making up the parts at the factory instead of in the home or field, and the simple *assembling* of these parts into the finished article.

With lead joints a far greater uniformity is obtained by making them at the foundry and shipping them as an integral part of the pipe to the job. The American Cast Iron Pipe Company ships these joints with pipe and the results are most satisfactory. A brief description of this prepared joint may not be out of place here, and the illustrations will serve to explain how it is made and installed.

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[3] The author desires to give all credit to J. R. McWane, president of the American Cast Iron Pipe Company, for the development of successful factory-made joints.

The finished pipe come down the pipe runs seen in the background of figure 1. Six pipe at a time are rolled onto the tilting platform here shown and thus are swung into a vertical position with the bell end up. When these pipe stand on end the bells are about 2½ feet above the overhead platform. Here stand two expert joint makers with the necessary equipment, whose first move is to insert a short mandrel into each of the six vertical bells.

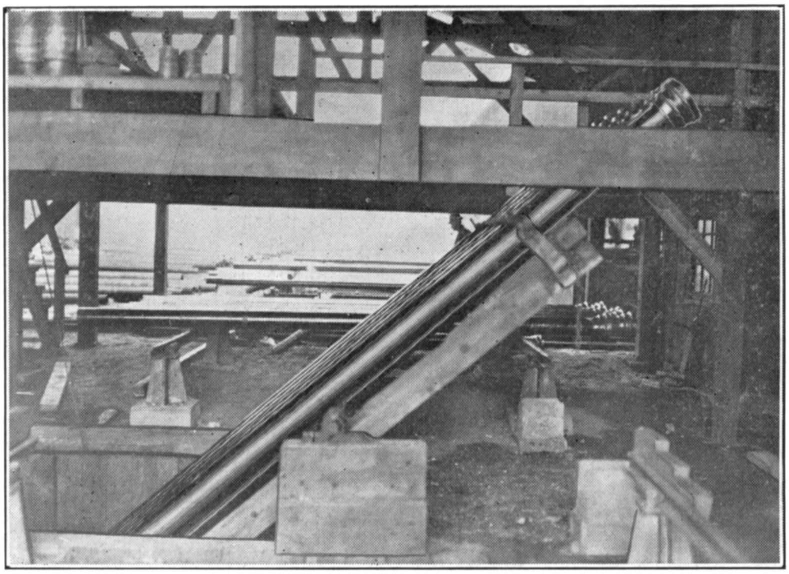
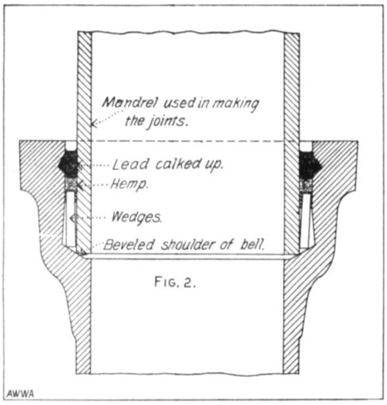


FIG. 1. TILTING PLATFORM, PARTLY UPENDED, USED IN HOLDING PIPE IN VERTICAL POSITION WHILE MAKING JOINTS

The bell on which this joint is furnished is the ordinary socket as to depth, diameter and other essential dimensions. The slight difference is that the bottom or shoulder of the bell is beveled off on a 30-degree angle as shown in figure 2, instead of being square. The lead groove, also, has been greatly improved by making it with a sharper shoulder so that the calking is much more positive. A band of iron wedges held together by a strip of lead is first inserted around the mandrel. Two layers of square hemp, especially braided for this purpose, are next inserted and calked on top of the wedges. Then hot lead is poured into the joint and the mandrel extracted, leaving all the joint materials in place.

A concrete plug, shown in figure 3, is inserted to protect the joint materials in shipment, and the pipe and joint are ready for the trench. This concrete plug is so designed that it may easily be broken out or jerked out of the bell by means of any convenient bent rod or the bent end of a pinch bar or crow bar on the job. One can thus actually look into the bell and see the condition of the joint materials before they are calked. This, of course, cannot be done with the ordinary joint, and is very important. It permits one to know absolutely that proper materials in proper amounts are in their proper place in the joint. Uniformity of construction is assured.



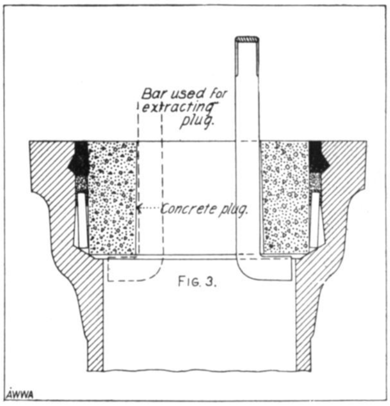


FIG. 2. CROSS-SECTION OF PARTLY COMPLETED JOINT

FIG. 3. METHOD OF REMOVING CONCRETE PLUG BY STRIKING ITS LOWER END WITH BENT BAR

Knowing the joint is right so far, the trench crew now inserts the spigot of the next pipe, which is so marked as to show when it is fully seated in the bell. The spigot is inserted easily because the mandrel over which the joint was made at the foundry is slightly larger in diameter than the spigot end of the pipe. All pipe with this joint are made without a bead on the spigot end. After inserting the joint "home" in the bell, the calker now simply takes his usual tools and calks the joints in the same way as he would the ordinary joint. With this joint, however, the lead is driven farther back and the force of the hammer blows penetrate to the hemp, which is thoroughly calked as well as the lead. Thus a better and tighter calking is possible. As shown in figure 5, the joints even on bends of short radii, are installed with ease and may be calked as tight as on straight runs.

The advantage of this prepared or factory-made joint, merely begins with its construction. The joint is designed to fulfil certain definite purposes after it is made. The inside shoulder of the bell, which has been referred to, figure 2, engages the iron wedges so that with the slightest deflection of a joint, these wedges are forced along the inclined shoulder and at the same time backward against the hemp and lead. Thus further compression, exerted internally, automatically tightens the joint as deflection takes place.

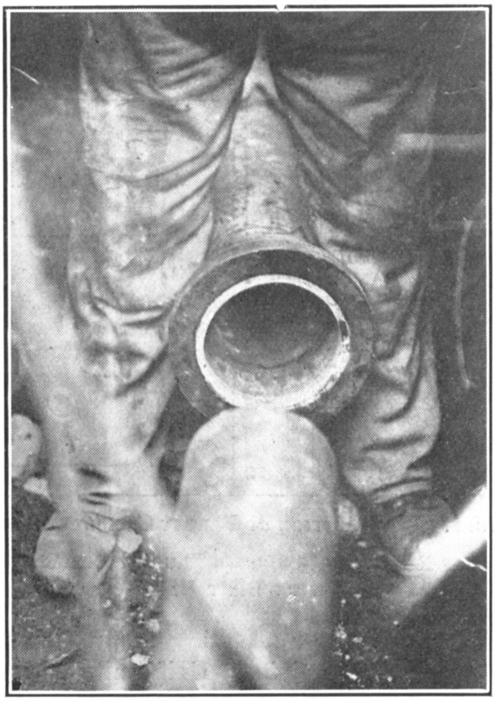


Fig. 4. Assembling Prepared Joint in Trench

The development of better joints for the conservation of expensive labor and materials and for the cutting down of losses through leakage is of great importance to pipe users. Equally important is the saving of high priced iron which may be conserved by improved methods of casting the pipe.

Light vs. heavy pipe. In America the development of the cast iron pipe industry has been basicly different from its development in Europe. As competition became keener year by year, the practice in all European countries has been to produce light walled pipe. Other factors have had their influence. For instance, the richer ore deposits became exhausted, fuel became scarcer, yet, on the other hand, to offset this, the better steam railway transportation has tended to decrease the cost of the raw iron. Indeed, because of cheap methods of transportation, iron has in one century been reduced in cost to a very low figure. During a period of less than a century in America pig iron dropped in price from $80 per ton to $8 per ton.

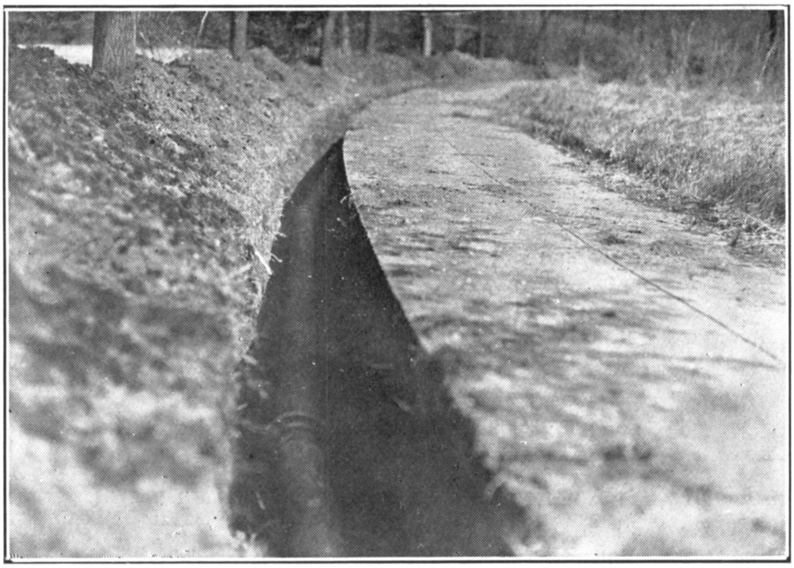


FIG. 5. CURVE OF 16-FOOT LENGTHS OF 6-INCH PIPE WITH PREPARED JOINTS; ALL JOINTS TIGHT ON TEST

The first American attempts at making pipe in 1820 to 1830 followed very closely the European practice as to wall thickness and design of hubs, spigots, etc. Moldenke in his book on *Principles of Iron Founding* states:

> Mention has been made that the cupola was not introduced into Pennsylvania until 1820. It came to New York City just a little later, for the well-known J. L. Mott Iron Works began operation in 1828 at Mott Haven, on the Harlem River, and there being no blast furnace about, used the cupola for making castings, importing patterns and some pig iron from England. On tearing down part of the old Astor House in 1913 some of the pipe and fittings made by this company in 1834 were found embedded in the original stone walls . . . . and are in a perfect state of preservation in spite of the fact that the metal in some of the pipe was but ⅛ inch thick when made.

These facts are given simply to point out that the American development of the cast iron pipe industry parted company with the European development some time between 1830 and 1870.

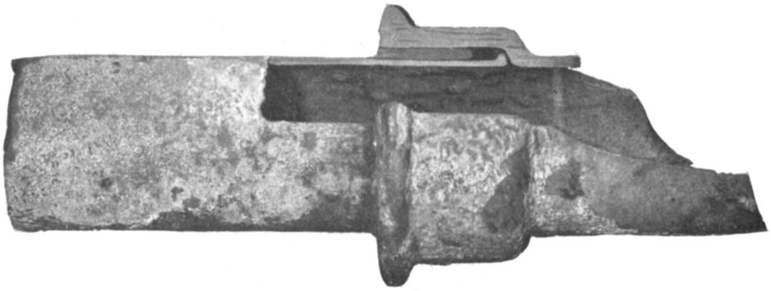


Fig. 6. Cast Iron Pipe Laid in Philadelphia in 1831 and Removed in 1915, after Continuous Service of 84 Years under Pressure of 50 to 100 Pounds. Thickness of Metal, ¼ to ⅜ Inch

Prior to the American Water Works Association specification of 1908, much of the pipe, especially in smaller sizes, was made of considerably lighter wall section. For instance, 4-inch pipe for 86 pounds pressure of the New England Water Works Association specification has a thickness of 0.38 inch as compared with 0.45 inch in the American Water Works Association specification for the same working pressure.[4] This is a difference of 16 per cent.

Many miles of the lighter piping have been in service for years. For instance, a pipe laid in Philadelphia in 1831 was taken out after a service of 84 years under pressures of 50 to 100 pounds. The metal thickness, ¼ to ⅜ inch, is much lighter even than the New England Association specification and corresponds closely to the thickness of pipe in Europe. See figure 6.

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[4] The 4-inch electric cast iron pipe for Class B service is 0.40 inch.

Because of high protective tariffs which kept out foreign trade, the great reduction in the cost of pig iron from $80 to $8 per ton, the competition in freight hauling railways which brought the transportation rates tumbling downward, and the lack of skilled foundry workmen which increased the percentage of defective castings, the American practice of making pressure pipe has been to repeatedly increase the metal thickness, while in Europe pipe has been made thinner to meet competition. The American pipe for given services in some instances is almost 50 per cent greater in thickness and weight. Even when shipping this lighter weight pipe from distant England and Germany to ports close by American shores, the excessively heavy American pipe could not compete in price for the single reason that the ocean transportation charges of the heavier American pipe were far in excess of the transportation charges of the lighter European pipe. Instead, America has for at least fifty years past been burying treasure under city streets; literally putting extra iron into the walls of cast iron piping throughout the country. America has had little chance to export pipe even when pig iron in Europe was of higher price.

Effect of the world war. The recent great war in Europe has completely changed America's attitude toward world trade. There has been a greater awakening on our part than ever before in our history. The prices of crude iron or pig iron have begun to soar, the temporary taking over of America's rail routes by the Federal Government has had the effect of increasing and standardizing the price of transportation, and the labor market has become so high in price that American manufacturers must necessarily feel inclined to use more and more labor-saving equipment in our mines and factories and in the work of erecting engineering structures in the field. With cast iron pipe 300 per cent higher in 1920 than in 1914, our municipal governments as well as private water and gas corporations, are hesitating to follow the past practice of burying under ground valuable treasure in the form of excessively heavy cast iron pipe. Entirely aside from the local effect in America, the situation as it respects export business is very similar. *Lighter pipe must be made if American manufacturers are to create and hold any trade in competition with foreign producers.*

On the other hand, from an engineering standpoint, American made pipe has been a more reliable and dependable product than the European pipe. Greater factors of safety have been used in the molding of pipe in America. The lower tensile strengths of cast iron have been assumed instead of the higher, and because the simplest and cheapest methods of remelting the iron in the cupola have been adopted, the tendency has been to put into the walls of the pipe plenty of safety factors to guarantee a reliable and safe product. The American idea has been to make the safety factors very essential and therefore make pipe with every assurance that it will not fail. Fire Underwriters insist upon underground piping that will not burst in time of stress. However, as will be pointed out, it is quite unnecessary at present to waste cast iron in pipe. Pipe may be made lighter but stronger.

The electric furnace. Foreseeing and anticipating the keen development which must necessarily take place in the American cast iron pipe industry, the American Cast Iron Pipe Company has been at work for five years studying the best equipment and methods of meeting the newer trade situations. The result of these investigations has been the addition of an electric furnace at its Birmingham plant. Electric furnaces are now in commercial operation in sizes to hold from $\frac{1}{4}$ ton to 20 tons of metal per heat. At present there seems no necessity for the construction of larger ones. The electric furnace installed at the Birmingham Plant is capable of handling in conjunction with the cupolas a total of approximately 300 to 400 tons of pipe castings per twenty-four hours.

The important result of passing iron through an electric furnace is to improve its physical properties to the following values: Tensile strength, 30,000 to 40,000 pounds per square inch, transverse strength, 2600 to 3500 pounds load, using a 2 by 1 by 24-inch bar; deflection of bar, 0.38 to 0.50 inch.

Furthermore, in Birmingham the actual work of melting the iron is reduced by taking advantage of the hot blast furnace metal from nearby smelting plants. This hot metal is mixed with the cupola metal in the electric furnace, thereby materially reducing the normal percentage of sulphur. Moreover, when the metal emerges from the heating and refining process of the electric furnace, its temperature is greatly raised so that sound pipe castings with higher factors of safety are assured. Tests of electric iron have proved the iron to be more uniform in structure and resultant strength; see table 1. Electric cast iron is of a dense, close-grained structure, but contains sufficient graphite to be easily machined. It has the same desirable rust-resisting property as any other close-grained, gray cast iron, and withal makes a superior pipe for underground work or for other uses to which cast iron pipe may be put.

The factors of safety which have been used with eminent success in the American pipe specifications, which are based on the well known Fanning formula, are practicable with even greater reliance when applied to electric cast iron pipe. This is well illustrated by Table 1 above, which gives the actual bursting strength of pipe. The big advantage of using electric cast iron is the lighter wall thickness permissible. On account of this increased strength and the greater structural uniformity of electric cast iron pipe, the American Cast Iron Pipe Company has given it the pressure ratings shown in Table 2.

TABLE 1

Actual bursting strength of cast iron pipe of 16-foot length

(Compiled from series of tests made at Birmingham)

SAMPLE NUMBER AND DESCRIPTION	WEIGHT OF PIPE	RATED WORKING PRESSURE	BURSTING PRESSURE	TENSILE STRENGTH OF TEST BAR	STRENGTH AT POINT OF BREAK	FACTOR OF SAFETY
	lbs.	*lbs. per sq. in.*	*lbs. per sq. in.*	*lbs. per sq. in.*	*lbs.*	
No. 72, 6 in., Electric...	450	86	1,360	33,700	12,300	15.8
No. 73, 6 in., Electric...	464	86	970	33,700	7,450*	11.3
No. 74, 6 in., Electric...	464	86	1,705	33,700	12,500	19.8
No. 66, 10 in., Electric...	916	130	1,310	35,400	16,100	10.1
No. 67, 10 in., Electric...	900	130	1,360	35,400	16,800	10.5
No. 68, 10 in., Electric...	1085	173	1,860	35,400	22,200	10.7
No. 69, 6 in., Ordinary.	540	130	1,460	25,000	11,200	11.2
No. 70, 6 in., Ordinary.	500	86	970	25,000	7,500*	11.2
No. 71, 6 in., Ordinary.	540	130	1,460	25,000	10,000	11.2
No. 63, 10 in., Ordinary.	1024	86	485	22,000	3,800†	5.5
No. 64, 10 in., Ordinary.	980	86	1,660	22,000	16,100	19.3
No. 65, 10 in., Ordinary.	954	86	1,260	22,000	14,500	14.6

* Minor flaws in iron.
† Bad flaws in iron.

It will be noted that there are four practical classes of pipe listed: Low Pressure, Standard, Heavy, and Extra Heavy. The Low Pressure is for class A or gas service, the Standard is for class B service, the Heavy is for class C service, and the Extra Heavy is for class D service. They are all made from class A patterns of the American Water Works Association specification, and are, therefore, of uniform outside diameter in the various classes.

Before closing this discussion on improved pipe specifications, a few words regarding allowable percentage of variation in weights of pipe might be of value. The American Water Works Association specification, adopted in 1908, states: "The total weight to be paid for shall not exceed for each size and class of pipe received, the sum of the standard weights of the same number of pieces of the given size and class by more than 2 per cent." No doubt, this clause has held certain advantages for the makers of pipe, but oftentimes the pipe user must, through this provision, pay 2 per cent more than what his original estimated cost per ton figure totaled. The pipe user is, therefore, at a disadvantage.

TABLE 2

Thickness and weights of electric cast iron pipe. In accordance with Fanning's formula, for electric cast iron of 30,000 pounds per square inch tensile strength

NOMINAL INSIDE DIAMETER	LOW PRESSURE PIPE FOR CLASS "A" SERVICE 0 TO 100 FEET HEAD					STANDARD PIPE FOR CLASS "B" SERVICE 100 TO 200 FEET HEAD					HEAVY PIPE FOR CLASS "C" SERVICE 200 TO 300 FEET HEAD					EXTRA-HEAVY PIPE FOR CLASS "D" SERVICE 300 TO 400 FEET HEAD				
	Thickness	Weight of 12 feet per		Weight of 16 feet per		Thickness	Weight of 12 feet per		Weight of 16 feet per		Thickness	Weight of 12 feet per		Weight of 16 feet per		Thickness	Weight of 12 feet per		Weight of 16 feet per	
		Foot	Length	Foot	Length		Foot	Length	Foot	Length		Foot	Length	Foot	Length		Foot	Length	Foot	Length
ins.	*ins.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*ins.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*ins.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*ins.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
4	0.38	18.0	215	17.8	285	0.40	19.0	230	18.7	300	0.42	20.0	240	19.7	315	0.43	20.5	245	20.2	325
6	0.40	27.7	330	27.5	440	0.42	29.2	350	28.8	460	0.44	30.8	370	30.3	485	0.45	31.7	385	31.2	500
8	0.42	38.7	460	38.2	610	0.44	40.7	485	40.0	640	0.46	42.9	515	42.2	675	0.49	45.7	545	44.6	715
10	0.45	51.5	620	50.5	810	0.48	54.3	650	53.1	850	0.50	57.1	685	55.9	895	0.53	60.8	730	59.2	950
12	0.48	65.7	790	64.1	1030	0.51	69.0	830	67.5	1080	0.54	72.5	870	71.2	1140	0.57	76.5	920	74.7	1195
14	0.51	80.7	970			0.54	85.0	1020			0.57	89.6	1075			0 60	94.2	1130		
16	0.54	96.8	1170			0.57	103.0	1235			0.60	108.3	1300			0.64	114.0	1370		
18	0.58	116.2	1400			0.61	122.6	1470			0.64	129.2	1550			0.68	135.0	1620		
20	0.61	135.5	1630			0 64	142.5	1710			0.67	150.0	1800			0.72	159.0	1910		
24	0.68	184.0	2210			0.72	194.0	2325			0.76	204.2	2450			0.80	217.0	2600		

It is believed to be for the best interest of the consumer when pipe is sold on a price per foot basis. This enables him to know exactly what his pipe line will cost him, whereas he might have to pay from 1 to 2 per cent excess charges on the price per ton basis.

Summarizing the vital points in favor of electric cast iron pipe and prepared factory-made joints, we are led to conclude as follows:

1. American manufacturers must produce stronger but lighter pipe if a balance of world trade is to be held on this side of the Atlantic Ocean.

2. By introducing an electric furnace into the pipe foundry, the American Cast Iron Pipe Company has been successful in producing higher factors of safety for pipe without an increase in cost.

3. The use of joints suitably prepared at the foundry instead of in the field leads to higher joint efficiency for underground pipe lines.

4. The users of pipe will further benefit by paying for pipe on the per foot basis, to say nothing of saving in hauling, handling, and laying.